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Maritime defense and security challenges

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About CMRE

The Centre for Maritime Research and Experimentation (CMRE) is a world-class NATO scientific research and experimentation facility located in La Spezia, Italy.

The CMRE was established by the North Atlantic Council on 1 July 2012 as part of the NATO Science & Technology Organization. The CMRE and its predecessors have served NATO for over 50 years as the SACLANT Anti-Submarine Warfare Centre, SACLANT Undersea Research Centre, NATO Undersea Research Centre (NURC) and now as part of the Science & Technology Organization.

CMRE conducts state-of-the-art scientific research and experimentation ranging from concept development to prototype demonstration in an operational environment and has produced leaders in ocean science, modelling and simulation, acoustics and other disciplines, as well as producing critical results and understanding that have been built into the operational concepts of NATO and the nations.

CMRE conducts hands-on scientific and engineering research for the direct benefit of its NATO Customers. It operates two research vessels that enable science and technology solutions to be explored and exploited at sea. The largest of these vessels, the NRV Alliance, is a global class vessel that is acoustically extremely quiet.

CMRE is a leading example of enabling nations to work more effectively and efficiently together by prioritizing national needs, focusing on research and technology challenges, both in and out of the maritime environment, through the collective Power of its world-class scientists, engineers, and specialized laboratories in collaboration with the many partners in and out of the scientific domain.

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COMMENTARY

Maritime Defense and Security Challenges

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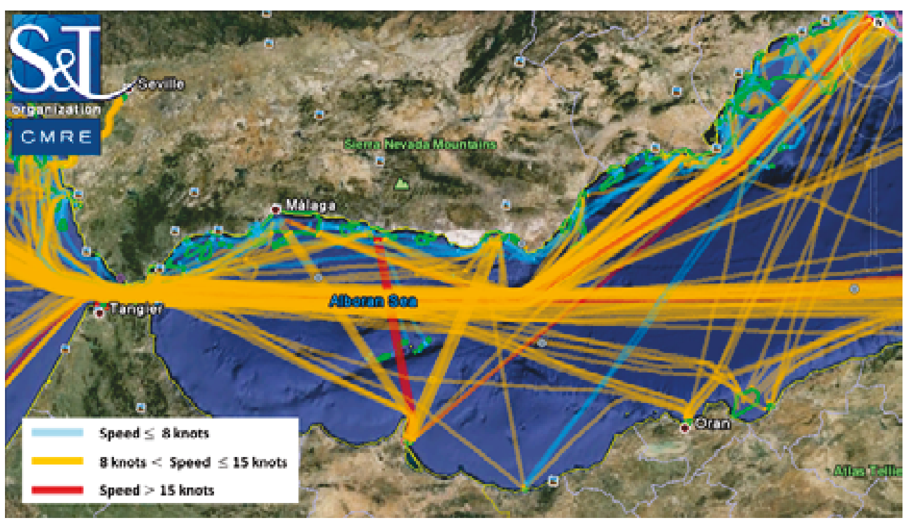
This commentary has its roots in a plenary presentation made at the IEEE/MTS Oceans conference and exhibition in Genova, Italy, in the spring of 2015. In the intervening year, the geopolitical landscape has continued to evolve apace, and in many ways, this has even more dramatically underscored some of the key messages in that talk.

Few would deny that the nature of maritime defense and security is changing rapidly. The threats we face, both within Europe and across the globe, are diversifying and becoming more complex. We no longer live in the comparative luxury of a world with a single "class" of easily identified and symmetric threats. Neither is defense and security any longer the exclusive domain of the military. The global interdependence of economies and our mutual dependence on sea lanes and safe harbors for the vast majority of trade make the defense and security of the maritime environment a global responsibility, with the protection of fisheries, offshore installations, and the maritime commons the legitimate concern of all nations and enterprises that rely on operations at sea. Today's maritime traffic patterns are complex and varied, as shown by an example route map estimated by CMRE's (Centre for Maritime Research and Experimentation) Unsupervised Traffic Route Extraction and Anomaly Detection (TREAD) tool in Figure 1, yet we must be able to detect anomalies within this highly structured context to identify security concerns. Every marine park threatened by illegal fishing; every offshore transport ship, oil platform, or wind farm; and every harbor or port with expensive or critical infrastructure need to be secured against pirates, terrorist attacks, and accidents. The issues of illegal human trafficking and refugees, so recently brought to the fore in the European Commission (EC) with thousands perishing in undocumented and poorly equipped vessels; of fighting the war on drug trafficking or illegal arm sales and shipments; and of embargo-breaking seaborne traffic all require maritime intelligence and security tools, such as TREAD, to be developed and made available to a broad spectrum of agencies.

Given the rapid escalation of the number and type of maritime threats to be addressed, combined with budgetary constraints, how can we expect to meet this challenge? To provide comprehensive security, we need not only military but also civilian and industrial agencies to work together, to both develop and apply effective dual-use technologies. This involves a shift from the traditional military role of shouldering the task of developing leading-edge technologies to passing some of the load to be shared with industrial partners. The impact is already obvious in Europe, where many government laboratories have been reduced in size, privatized, or amalgamated, while entrepreneurial companies have taken up the baton and are now leading the charge in innovative science and technology research and developments that are being applied in multiple roles.

FIGURE 1

A route map for the western Mediterranean produced by the center's TREAD tool visualized via Google Earth. Shipping routes (color coded according to speed class) have a thickness proportional to estimated traffic density. (Color version of figures are available online at: http://www.ingentaconnect.com/content/mts/mtsj/2016/00000050/00000004.)



However, what kind of technologies do we need? Incremental improvements in existing tools will only carry us so far and are unlikely to deliver the performance level and flexibility we require. We need game-changing advances, a paradigm shift brought about by disruptive technology. At the CMRE, we believe that maritime autonomy, not simply unmanned, but intelligent autonomy, could be a big part of the answer. With autonomous systems that are smart enough to adapt their behavior to the environment they find themselves in, optimizing their sensing and communications to create the best possible picture from a distributed network of heterogeneous sensor platforms, we have a paradigm that is potentially less expensive, more spatially diverse, more agile, and more effective than fielding relatively few, expensive, manned platforms. In concert with existing manned systems, maritime autonomy has the potential to be a force multiplier, taking the man out of the loop in dangerous or hostile environments and significantly enhancing capabilities. The center is developing a range of novel sensor payloads for such autonomous vehicles; an example of which is seen in Figure 2, which shows a compact acoustic array that allows a silent glider to profile the seabed by interpreting scattered ambient noise in the ocean.

FIGURE 2

An autonomous glider being fitted with a compact 3-D sensing array of hydrophones (four of which are shown with temporary protective gray foam covers).

That being said, there are significant challenges and much to do in terms of establishing standards for interoperability and in de-risking innovative technologies to provide reliable value. Interoperability cannot be built in after the design, at least not at a reasonable cost. However, this is crucial in achieving the scalable and leveraged benefits that are available from distributed heterogeneous networks, in which every ship, platform, and robot is a sensing node in the network. It is therefore imperative that we reach out across the traditional military, civil, and industrial divides to cooperate and synergize in building this future capability tool set. We now stand at a tipping point, where there are still important limitations to overcome but where the existing capability is becoming effective and reliable enough to begin to be embraced beyond university laboratories and research centers, into a marketplace that is orders of magnitude larger—mainstream users who want turn-key products.

In the road ahead, the challenges are not all technical (although the remaining technical problems are far from trivial). It is all too easy to underestimate the resistance to change from cultures with well-established operating paradigms and procedures. To effectively leverage existing (usually "manned") capabilities, we will need to address the psychological, social, and ethical aspects of progressively blending in autonomous capabilities, engaging all stakeholders, and piloting our way forward with clear, visionary leadership in a spiral development of learning by doing, refining, and reapplying. We will need to develop new business models and cross-disciplinary partnerships to address these multidisciplinary issues. We will also need to extend and expand our communications to build in modular interoperability from the ground up, so that we can scale our systems and build effective ad-hoc networks that are robust and that degrade gracefully to dropouts. There are powerful lessons to be learned here from the development of unmanned aerial systems, a field that has already grown past many of these teething pains, but not always smoothly.

Turning to some specific examples of this kind of collaborative development, CMRE is participating in a number of EC-funded projects to develop critical technologies that will support future autonomous systems. For example, in ICARUS,[1] the center has developed robotic tools that can assist "human" crisis intervention teams in search and rescue missions. The MORPH project[2] is investigating how to combine several heterogeneous underwater vehicles to cooperate as a single system in complex environments, while SUNRISE[3] is developing interoperable communication tools for the future underwater Internet of things. The PERSEUS project[4] successfully developed an autonomous underwater glider with the capability to acoustically and stealthily detect small, fast surface craft. The vehicle was equipped with onboard real-time signal processing that provided information to an intelligent mission control package that could react autonomously to detections and take appropriate action. This "intelligent autonomy package" is a modular element, which

[1]http://www.fp7-icarus.eu
[2]http://morph-project.eu
[3]http://fp7-sunrise.eu
[4]https://www.perseus-fp7.eu

FIGURE 3

A modified WaveGlider communications gateway being deployed from the NATO Research Vessel Alliance.

facilitated its subsequent installation on a "WaveGlider," a commercially available autonomous surface vehicle. Figure 3 shows a modified WaveGlider being deployed during a sea trial, adapted by CMRE to serve as an intelligent communications gateway and cooperative navigation node, linking underwater with in-air radio networks.

In yet another collaborative research project, ARGOMARINE,[5] CMRE integrated acoustic sensing capabilities into an automated oil spill monitoring network. CMRE is also working closely with our primary client in NATO to generate maritime autonomy standards for NATO-wide implementation.

These kinds of developments are finding real-world applications, delivering cost-effective impact. The United Kingdom is now using a WaveGlider to detect illegal fishing in the world's largest, continuous marine reserve (834,000 km^2) in the Pacific.[6] Data gathered by the WaveGlider are sent back by the satellite to a monitoring and control center to help prosecute unauthorized trawling in the reserve.

The maritime defense and security environment is ever changing, and new challenges are now emerging at an unprecedented rate. Maritime autonomy is a disruptive technology that holds promise to unlock the next generation of powerful tools to secure our future, but only if we can collaborate and develop these tools in a comprehensive and interoperable way. Our window of opportunity is closing fast as the technologies transition from a niche research area into mainstream applications. CMRE, as a not-for-profit multinational research center, is keen to build partnerships with stakeholders across the board in the interests of open framework, modular maritime innovation that goes beyond the concept of "dual use" and embraces the truly pan-cultural responsibility of securing our maritime commons for all.

[5] http://www.argomarine.eu/

[6] http://www.bbc.com/news/technology-35783564

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